REMOTE ENGINE STOP/START SYSTEM WITH BACKUP MOTOR CONTROL

REFERENCE TO RELATED APPLICATION

This application claims priority from provisional application serial number 60/477,908 filed June 12, 2003.

BACKGROUND OF THE INVENTION

[0001] 1. Technical Field:

[0002] The invention relates to power take off systems for utility vehicles and more particularly to a system providing remote starting and stopping of the vehicle and for control of an emergency back up motor to the power take off system.

[0003] 2. Description of the Problem:

[0004] Utility vehicles are often advantageously supplied with auxiliary equipment the operation of which is supported by the vehicle. Such auxiliary equipment can include hydraulically powered, aerial lift buckets that are often used for the repair of electrical power distribution lines. Typically, a hydraulic lift platform will be driven by a pump which is in turn driven by the vehicle's engine. In some applications, a back up prime mover, e.g. an electrical motor, is provided for the pump. A bucket at the end of the aerial lift system is electrically isolated to allow the worker to work on power lines which are still hot.

[0005] Trucks may come equipped with controls to allow a worker supported in the bucket to remotely shut off and turn on the vehicle's engine and to remotely raise and lower the lift. To avoid providing a conductive electrical path between the bucket and the truck, the controls located in and around the bucket for the operator's use are usually pneumatic. An air line is connected between the bucket, where a plunger-actuated piston is positioned, and a pneumatic, pressure actuated, electrical switch on the truck. To avoid expense a minimal number of pneumatic lines is provided. A problem addressed by the invention is providing a single, pneumatic, pressure actuated electrical switch which can be used to both start and stop a truck's engine, and in some applications, allow activation of a back up hydraulic pump in case of engine failure. Complicating the effort to construct such a device is the

susceptibility of vehicle electronics to resetting during engine starting due to voltage fluctuations.

[0006] Industry standards specify that the bucket control for an aerial lift truck having an emergency or back up pump shall: (1) if the engine is running and the remote switch is closed (regardless of the duration for which it is held closed), shut down the engine; (2) if the remote switch is kept depressed for more than 3 seconds following a remote engine stop, cause the emergency or back up pump to operate and to continue to operate for as long as the switch is held closed; (3) if the remote switch is cycled following a remote stop or following the operation of the emergency pump, cause the engine to crank for the duration of the switch closure; and (4) if the engine does not start after cranking, respond to cycling the remote switch by causing the emergency pump to operate for as long as the remote switch is depressed.

[0007] Contemporary vehicles are commonly equipped with an electrical systems controller/body computer (ESC) and a controller area network allowing data transfer between the ESC and other controllers, including an engine controller and a transmission controller. These systems are built in conformance with the Society of Automotive Engineers' J1939 standard. Remote engine and bucket position control must be implemented in a way that cranking and shut down of the engine is effected only by closure of a hard-wired, ground side switch. This remote switch must be designed in the system hardware and be independent of the ESC's software. The hardware architecture cannot depend upon the ESC remaining active during engine cranking and must continue to function even if the ESC temporarily fails and reinitializes due to transient low voltage.

[0008] The status of the ESC cannot be allowed to interfere with normal starting and stopping of the engine using the standard four-position key ignition switch. It must remain possible to crank the engine even when the vehicle is latched in the remote start mode. This allows ground personnel to start the engine and engage PTO operation to lower a boom should the operator be disabled. It is permissible to allow momentary cycling of the key ignition switch to cancel remote stop mode. The system shall prevent engine cranking in response to closure of the remote switch if the hood is open. The hood disable feature must also be independently operable without reference to ESC status. However, the backup pump motor must be operable with the hood open.

[0009] The backup motor and solenoid should not be operated for any duration of time, or briefly cycled on and off, unless the conditions for emergency operation have been met. The backup motor brushes and solenoid contact life may be compromised by repeated, brief duration operation at high

surge current levels. Remote switch operation should not result in application of any current to the backup motor and solenoid unless and until its operation is necessary.

[0010] The system shall permit the engine to crank only so long as the remote switch is closed. Once the remote switch opens, cranking should immediately stop, allowing only for some delay where the remote switch is pneumatically actuated. The system shall not allow the engine to crank unless the parking brake is set. This requirement can be met by modification of ESC software. The system shall not allow remote engine shut down unless a J1939 compliant engine RPM message is present on the vehicle databus from an engine controller. This requirement prevents stranding an operator in a boom since the engine will not crank remotely if an engine RPM message is not present.

SUMMARY OF THE INVENTION

[0011] According to the invention there is provided a motor vehicle having a remote switch by which the vehicle's engine may be shut down and restarted. In some applications the same switch may be used to engage a backup electric motor energized from the vehicle's battery as a substitute prime mover for a power take off apparatus installed on the vehicle. The invention provides a vehicle engine ignition control system having a starter solenoid and motor and engine control electronics. A multiple position ignition switch provides energization to the ignition control system in response to positioning of a key switch, as is conventional. The ignition switch has two output terminals which assume energized states in response to the positioning of the key switch. A first output is energized when the key switch in placed in a start position. A second output is energized when the key switch is in either the ignition position or the start position and may be energized when the key switch is in an accessory position. A remote switch is located on the vehicle away from the multiple position ignition switch, typically in a bucket suspended by an aerial boom. The remote switch provides a connection to ground when closed. An electrical systems controller communicates with the engine control electronics and is coupled to the remote switch to be responsive to closure of the remote switch in accordance with its programming. Responses include providing various enable signals and/or ground connections enabling operation of selected portions of the ignition control system. A remote start relay is coupled to respond to a remote start energization signal sourced by the electrical systems controller if it occurs concurrently with closure of the remote start switch. The remote start relay provides an activation signal on an output which is applied to a starter relay. The starter relay responds to the activation signal by providing activation energization to the starter solenoid and motor.

[0012] Remote stop of the engine is provided by control of a chassis ignition relay, which couples an ignition signal (Ign) from the ignition switch to an engine controller. A remote switch state detection relay is coupled to the remote switch and to the second output of the multiposition ignition switch and is responsive to the concurrent occurrence of an energization signal on the second output of the multiposition ignition switch and closure of the remote switch to generate a remote stop energization signal. The electrical systems controller is further responsive to closure of the remote switch and to indication that the engine is operating (by reading an engine RPM signal from the engine controller) for providing a ground connection through an input. A remote stop relay provides coupling of energization from the multiple position ignition switch to the chassis ignition relay. The chassis ignition relay is connected to the remote switch state detection relay to receive the remote stop relay energization signal and is further connected to the input of the controller, the remote stop relay being responsive to the remote stop energization signal and grounding of the ground side of its energization coil through the controller input for interrupting energization of the chassis ignition relay and thereby cutting the Ign signal to the engine controller, resulting in interruption of operation of the engine.

[0013] Where a vehicle is equipped with backup prime mover for a vehicle power take off (PTO) apparatus, the ignition system further includes a backup motor and solenoid connected to the vehicle electrical power source. A backup motor inhibit relay is connected across the power connection to the backup motor and solenoid to prevent any undesired operation of the motor, however brief. A backup motor relay is coupled to receive energization from the remote start relay and is further coupled to the remote switch to be responsive to concurrent closure of the remote switch and application of the energization signal from the remote start relay for coupling energization signal from the remote start relay to the backup motor inhibit relay as an input. Finally the electrical systems controller provides a connection to ground on an inhibit input in response to the key switch being in the ignition position and engine cranking having been attempted and failed.

[0014] Additional effects, features and advantages will be apparent in the written description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an

illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

[0016] **Figure 1** is a simplified illustration of a truck mounted aerial lift assembly for locating an operator in various raised positions.

[0017] **Figure 2** is a high level schematic of a vehicle electrical and hydraulic control system incorporating the invention for the truck of **Fig. 1**.

[0018] **Figure 3-10** are a series of circuit schematics of a remote ignition control system in accordance with two embodiments of the invention.

[0019] **Figures 11-12** are high-level flow charts of programs executed by a system electronics controller in implementing aspects of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0020] Referring to the drawings, and particularly to **FIG. 1**, an example of a mobile aerial lift truck **1** is illustrated in simplified presentation for clarity of illustration. The mobile aerial lift truck **1** includes an aerial lift unit **2** mounted to a bed on the back portion of the truck. The aerial lift unit **2** includes a lower boom **3** and an upper boom **4** pivotally interconnected to each other and to the truck bed through support **6** and rotatable support bracket **7**. A bucket/basket **5** is shown secured to the outer end of the upper boom **4** within which the operating personnel are located during the lifting to and locating within a selected work area in accordance with known practice. Basket **5** is typically pivotally attached to the out end of the boom **4** to maintain a horizontal (level) orientation at all times. The aerial lift unit **2** is mounted to the truck bed through support **6**. A rotatable support bracket **7** is secured to the support **6** and projects upwardly. The lower boom **3** is pivotally connected as at pivot **8**, to the rotatable support bracket **7**. A lifting lower boom cylinder unit **9** is interconnected between bracket **7** and the lower boom **3**. In the illustrated embodiment, a pivot connection **10** connects the lower boom cylinder **11** of unit **9** to the bracket **7**. A cylinder rod **12** extends from the cylinder **11** and is pivotally connected to the boom **3** through a pivot **13**. Lower boom cylinder unit **9** is connected to either of two hydraulic supplies of a suitable hydraulic fluid, which allow the assembly to be lifted and lowered as desired.

[0021] The outer end of the lower boom **3** is interconnected to the lower and pivot end of the upper boom **4**. A pivot **116** interconnects the outer end of the lower boom **3** to the pivot end of upper

boom. An upper boom/compensating cylinder unit or assembly **117** is connected between the lower boom **3** and the upper boom for pivoting the upper boom about pivot **116** for positioning of the upper boom relative to the lower boom. The upper boom/compensating cylinder unit **117** is constructed to permit independent movement of the upper boom **4** relative to boom **3** and to provide a compensating motion between the booms to maintain the upper boom raising with the lower boom and is similarly connected to the sources of pressurized hydraulic fluid as further developed below. Conventionally, aerial lift unit **2** requires positive hydraulic pressure both to be lifted or to be lowered. Bucket **5** includes a plunger moving a piston in an air line. The air line runs from bucket **5** to a point on truck **1** where a remote switch, as described below, is located.

[0022] **Fig. 2** is a block diagram schematic illustrating electronic control of a truck **1**, based on controller area network technology and an electrical systems controller/body computer (ESC) **24**. Collectively, bus/data link **18** and the various nodes (generally the various vocational controllers described below) to which it is attached form the controller area network (CAN), which conforms to the SAE J1939 standard. Controller area networks are networks which do not have destination addresses for nodes attached to the networks, but rather provide for transmission of data in packets, identified as to the source, message type and priority. The nodes are programmed as to whether to respond to a packet based on one or more of three identifiers. Many message types are predefined by the SAE J1939 standard. The SAE J1939 standard allows the definition of proprietary message types which in structure conform to the standard.

[0023] Active vehicle components are typically controlled by one of a group of autonomous, vocational controllers. These vocational controllers include ESC **24**, an engine controller **20**, a electrical gauge controller **14**, a transmission controller **16**, an anti-lock brake system controller **22**, and a remote power take off controller **57**. ESC **24** and engine controller **20** are of primary interest to the present invention. Transmission controller **16** is provided with vehicles equipped with automatic transmissions and generates a signal indicating whether the vehicle's drive line is engaged or not. It is preferred at the time this application is being written that application of the invention be limited to vehicles equipped with automatic transmissions due to the lack of a indicator on vehicles equipped with standard transmissions as to whether the vehicle drive line is disengaged. Should such an indicator be made available the invention can be used on vehicles equipped with standard transmissions. Engine controller **30** provides an engine RPM signal, which is required for implementing certain routines in ESC **24**. The engine controller **20** also receives certain signals implicated in engine operation. ESC **24**, through discrete input ports **50** and output ports **52**, provides selective enable signals and ground

connections, and detects the state of a remote switch used for remotely starting and stopping the vehicle's engine.

[0024] The hydraulic lift unit **58** which supports operation of an aerial lift unit **2** is primarily powered by a conventional PTO hydraulic pump **60** which is usually driven by engine **30**. Backup to engine **30** for powering hydraulic pump **60** is provided by a backup solenoid and motor **54**, energized from vehicle battery **21**. Energization of backup solenoid and motor **54** is controlled in part by programming of ESC **24** and control signals issued by it through discrete outputs **52** coupled into the starter system **100** and a pump inhibit relay **46**. Energization for backup solenoid and motor **54** is supplied by battery **21** as controlled by a pump relay **36** and the pump inhibit relay **46**. ESC **24** also controls remote starting and stopping of engine **30** by control signals provided to starter system **100** which in turn provides control signals to a starter solenoid and motor **59** and engine controller **20**. Battery **21** charge is maintained by an engine **30** driven charging system **47**. ESC **24** also monitors the position of a parking brake and a PTO on/off switch. PTO on/off switch is located in a multiplexed switch pack **43**, monitored on the J1708 switch data link **49**. The parking brake is a discrete switch input **50**.

[0025] Referring to **Figures 3-7**, a preferred embodiment of the starter system **100** as applied to a vehicle not having a backup hydraulic pump motor is illustrated. Starter system **100** provides for starting and stopping an internal combustion engine **30** from either inside a vehicle cab using an ignition switch **102** or from a remote point on the vehicle using a remote switch **110**. Remote switch **110** is a ground side, momentary contact switch with a default open state. Remote switch **110** is pneumatically actuated using a plunger **117** into an air line **111**. Ignition switch **102**, as is conventional, has four position: (1) accessory/Acc; (2) off; (3) ignition; and (4) start. Ignition switch **102** has first and second mechanically linked switches **106** and **108**. Switch **106** has an output connected to the start contact of the switch. For switch **108** the ignition and start position are tied together for output **115**. Ignition and Accessory/Acc positions are tied together when the key switch is either of these positions. Accessory/Acc is a discrete input to the ESC **24**. Acc has +12V anytime the key is in the accessory or ignition positions. Accessory drops out with the key switch in the crank position, which permits the invention to detect that the key switch is in the crank position during a remote stop period, such as the case where someone in the cab cranks the engine should the operator in the boom not be able to start the engine remotely (e.g. when the operator is unable to press the remote button. Switch **108**, as described below, allows for remote stopping and starting of an engine using remote switch **110**. Ignition switch **102** is key actuated and is energized through a 5 amp fuse **104** from battery **21**. For clarity of presentation, the off and ignition contacts for switch **106** are shown as floating, their operation

not effecting the invention. The accessory contact of switch **106** provides power as an input to the ESC **24**.

[0026] Remote switch **110**, ignition switch **102** and the various relays used in implementing starter system **100** interact with programmable controllers which communicate with one another over the J1939 datalink **18**. ESC **24** and engine controller **20** monitor the state of various signals and provide enabling signals (including signals characterized by a ground connection through the controller) which implement aspects of the invention. Transmission controller **16** provides a driveline engagement indication signal used by engine controller **20** which inhibits cranking should the transmission engagement signal indicate the transmission (not shown) is in neutral or park. Some operations of starter system **100** can however be invoked notwithstanding temporary failure of the programmable controllers. ESC **24** is illustrated sectioned into two parts, one associated with electrical connections outside of a vehicle cab and a second section inside the vehicle cab. ESC **24** is usually one device and the division is simply for convenience of illustration. Adapting starter system **100** for remote operation must be done in a way that does not change normal operation of a vehicle. Accordingly, switch **106**, when moved to the start position, supplies power to a sense input (PIN 86) of starter relay **112**. This causes starter relay **144** to close thus supplying power from battery **21** through fuse **144** to the output associated with PIN 87 of the starter relay and from there to a starter solenoid and motor **59**. Engine controller **20** provides a ground to PIN **85** of starter relay **112** through a transistor switch **126** which is biased into conductivity in response to a gate signal provided by microprocessor **124**.

[0027] Remote operation is possible when ignition switch **102** is placed in the "ignition position". This places both of switches **106** and **108** in the ignition position, supplying power to node **115** which is tied to the second output of ignition switch **102**. Remote operation is invoked by closing momentary contact remote switch **110**, the effect of which is to connect to ground node **113**, which is normally biased high by ESC **24** from a sensor input **130**. The closure of remote switch **110** is detected by ESC **24** through sensor input **130**. The closure of remote switch **110** also grounds the ground side contact for the sense coil of a remote start relay **138** and the ground side contact for the sense coil of a remote switch state detect relay **132**. Assuming initially that engine **30** is running, the closure of remote switch **110** results in engine **30** being shut down. Since switch **108** is in the ignition position power flows from node **115** to the high side contact for the sense coil for remote switch state detect relay **132**, and the relay closes, supplying power from ignition switch **102** through remote switch state detect relay **132** to the high side sense input of remote stop relay **114**.

[0028] Upon detection of closure of remote switch **110** ESC **24** determines if the conditions for remote stop are present, e.g. (1) parking brake set, (2) Engine RPM signal non-zero, etc. If all the conditions are met, ESC **24** will provide a ground connection through transistor **132** (an RD15 low side driver) to the low side contact for the sense coil of remote stop relay **114**, resulting in the relay opening and the transfer of power through the remote stop relay being interrupted. When remote stop relay **114** opens, three ignition relays **116, 118** and **120** are all interrupted, with the result that power to all ignition powered features of the vehicle are interrupted. Chassis ignition relay **116** provides an ignition signal (Ign) via fuse **122** to engine controller **20** and microprocessor **124**. Engine controller **20** in turn carries out a shut down of engine **30**. Power is also interrupted to transmission controller **16.**

[0029] When the user releases remote switch **110**, DIN 19 on ESC **24** detects an increase in voltage at node **113** indicating to ESC **24** that the remote switch has opened. Remote switch state detect relay **132** is deenergized due to loss of a connection to ground on the low side of the switch state detect relay's sense coil. Remote stop relay **114** remains energized (i.e. latched) because the high side of the remote stop relay sense coil is tied to DIN 87 of the relay and ESC **24** continues to provide a ground connection to the low side of the remote stop relay's coil.

[0030] Remote start is explained with reference to **Fig. 4**. Again a user causes remote switch **110** to close and holds the remote switch down. Engine **30** cranks for as long as remote switch **110** is held closed. Upon closure of remote switch **110** node **113** drops to ground, an event which is detected by sensor **130** (DIN 19) of ESC **24**. The voltage drop causes remote switch state detect relay **132** to trip to a closed state, an operation which has no other effect on circuit operation. In response to the fall in voltage ESC **24** determines if the conditions for remote start are met. If the conditions are met, ESC **24** removes the gate voltage from transistor **134** cutting off conduction through the device. At this point the remote stop relay **114** deenergizes, reconnecting the high sides of the energization coils for the three ignition relays **116**, **118** and **120**, to power from multiple position ignition switch **102**. The low side contacts for the sense coils for all three of the ignition relays **116**, **118** and **120** are connected permanently to chassis ground so all three relays are automatically reenergized. The signal Ign to engine controller **20** is thus restored and transistor **126** is energized to connect the ground side of the energization coil of starter relay **112** to ground. Ign also indicates to the engine controller **20** that other ignition management functions are to be implemented.

[0031] ESC **24** must carry out certain actions to enable an engine restart in response to closure of remote switch **110**. The response to the detected voltage drop on node **113** includes ESC **24** driving

output **136** high. With output **136** high and node **113** low, a voltage difference appears across the contacts of the sense coil for remote start relay **138** and the relay becomes energized. Provided the vehicle hood is closed (thus closing a hood safety switch **142**), power will be coupled through remote start relay **138** to the sense coil high side input (DIN 86) of starter relay **112** from node **115** with the key switch of the multiple position ignition switch **102** in the ignition (Ign) position. With starter relay **112** energized, energy is coupled through the starter relay from battery **21** to starter solenoid and motor **59** to initiate cranking.

[0032] High surge currents delivered to starter solenoid and motor **59** may cause a system voltage drop which may result in ESC **24** resetting. If this occurs transistor **134** remains in a non-conductive state which is desired. However, output **136** can fail. Accordingly, it is desirable to provide a means of latching remote start relay **138** in an energized state for cranking, since cranking will cease if remote start relay **138** deenergizes in response to loss of the signal from output **136**. See **Figure 6**. To effect latching of remote start relay **138** a diode **140** is provided oriented to conduct electricity from DIN 87 (the normally open contact) of remote start relay **138** to the high side contact of the energization coil for the relay. Once remote start relay **138** is energized, and for as long as remote switch **110** is closed, the relay will remain latched by way of a forward biased diode **140**. This of course requires the ignition switch **102** remain in the Ign or St position. If Ignition switch **102** is moved to the OFF position, it will of course deprive the output DIN 87 of power and remote start relay **138** will be deengergized. Release of remote switch **110** deprives the ground side contact of the energization coil of the remote start relay of a ground connection also resulting in deenergization of the relay. See **Figure 7**.

[0033] A diode **140** is used instead of a wire connection to provide a latch mechanism for remote start relay **138**. Were a wire used to connect the contacts of remote start relay **138**, anytime a high signal appeared on output **136** of ESC **24** the engine would crank. Since ESC **24** is subject to reprogramming and field maintenance the possibility that the device could be reprogrammed or rewired cannot be discounted. The engine crank inhibit low side driver (sensor input **130**) is a relatively low impedance path to ground from node **113** when the transmission is in neutral. It could function to pull down node **113** enough to be detected as closed remote switch.

[0034] Referring to **Figures 8-10** a second embodiment of the invention incorporating an emergency pump motor and solenoid **54** is described. The remote start/stop circuit **100** of **Figures 3-7** is unchanged except for the addition of the emergency motor and associated control relays. As with the remote start operation, operation of the emergency motor is to be invoked using remote switch **110**.

An additional connection to ESC **24** is also provided to allow ESC **24** a certain degree of control over remote operation of emergency pump motor and solenoid **54** although the circuit provides for failsafe operation of the emergency pump motor should ESC **24** fail.

[0035] Normally the operation of emergency pump motor and solenoid **54** is inhibited by ESC **24**. This is effected by ESC **24** energizing transistor **146** to provide a pump inhibit signal (a ground contact) to the low side contact of the energization coil of pump inhibit relay **46**. The high side contact of the energization coil of pump inhibit relay **46** is connected to node **115**. As a result, pump inhibit relay is energized and no activation signal can flow from the relay to emergency pump and solenoid **54**. See **Figure 8**.

[0036] Emergency pump operation following a remote stop occurs when a user/operator keeps remote switch **110** depressed after a remote engine shut down. Remote start relay **138** is not energized, so ignition voltage is supplied from multiple position ignition switch **102** via node **115** to the high side sense coil contact of pump relay **36** energization coil and to the power input contact of the pump relay, the two contacts being in common. See **Figure 9**. With the ground side contact of the energization coil of pump relay **36** at ground, the response of pump relay **36** is to energize supplying power to DIN 30 (common terminal) of pump inhibit relay **54**.

[0037] ESC **24** times the duration of closure of remote switch **110** and when three seconds have expired deenergizes transistor **146** depriving a connection to ground for the ground side contact of the energization coil of pump inhibit relay **46**. Pump inhibit relay **46** deenergizes connecting the common terminal of the relay to output DIN 87A and thereby supplying an activation signal to emergency pump motor and solenoid **54**. See **Figure 10**. The deenergized pump inhibit relay **46** supplies ignition voltage to the emergency pump motor solenoid resulting in energization of the emergency pump motor. Emergency pump motor and solenoid **54** operates as long as remote switch **110** is held closed. Opening remote switch **110** causes pump relay **36** to deenergize, interrupting the signal to the common terminal of pump inhibit relay **46** which in turn deenergizes depriving emergency pump motor and solenoid **54** of an activation signal. In addition, when remote switch **110** is released the voltage on node **113** increases, which is detected by ESC **24** which responds by energizing transistor **146** and thereby energizing pump inhibit relay **46** until ESC **24** again determines that the conditions for emergency pump motor operation are met. Were there no pump inhibit relay **46**, any closure of remote switch **110** would cause emergency pump motor and solenoid **54** to briefly operate, which has the potential of decreasing the life of the solenoid and motor.

[0038] Operation of emergency pump motor and solenoid **54** can also occur after an unsuccessful engine crank. ESC **24** maintains pump inhibit relay **46** in an energized state until the conditions for emergency pump motor and solenoid **54** operation are met. Following a crank attempt which fails, an operator releases remote switch **110** to discontinue cranking. The operator then depresses remote switch **110** and holds it closed to initiate operation of the emergency pump motor and solenoid **54**. See **Figure 9**. ESC **24** will detect the closed remote switch **110**. Even though the engine is not running, ESC **24** does not initiate a crank operation (by supplying the appropriate signals at output **136** and changing the state of transistor **134**) since the last command was to crank the engine. ESC **24** is programmed instead to engage emergency pump motor and solenoid **54** following a failed cranking attempt, even if ESC **24** suffered a reset due to low battery voltage during cranking. Three seconds after remote switch **110** is closed ESC **24** deenergizes transistor RD13 **146**. This in turn deenergizes pump inhibit relay **46**. Closure of remote switch **110** has already supplied a ground connection to the ground side contact of the energization coil of pump relay **36**, resulting in the pump relay becoming energized. Deenergized pump inhibit relay **46** supplies ignition voltage from pump relay **36** to emergency pump motor and solenoid **54** and the emergency pump motor begins to operate until remote switch **110** is released. Opening of remote switch **110** causes pump relay **36** to deenergize, interrupting ignition voltage to pump inhibit relay **46** and cutting off power to emergency pump motor and solenoid **54**. Pump inhibit relay **46** remains energized by a reenergized RD 13 transistor **146** until the conditions for emergency pump motor operation are again met.

[0039] Emergency pump motor and solenoid **54** operation are also available in case of a complete failure of ESC **24**. If ESC **24** fails, the pump inhibit signal from RD 13 transistor **146** also fails and the pump inhibit relay **46** deenergizes. If battery voltage is still available, ignition voltage is still present on the high side contact and common contact for the energization coil of pump relay **36**. When remote switch **110** is depressed pump relay **36** energizes and couples ignition voltage through to the common contact of now deenergized pump inhibit relay **46**. Pump inhibit relay couples the ignition voltage through to emergency pump motor and solenoid **54** which is energized whenever, and for as long as, remote switch **110** is closed. No three-second delay occurs for pump operation under conditions of failure of ESC **24**.

[0040] **Figures 11** and **12** are flow charts for programming of ESC **24** to implement certain features of the present invention for the embodiment not incorporating and the alternative embodiment incorporating an emergency pump motor, respectively. The programs implement logical testing for the conditions under which the vehicle's engine is stopped or started and the emergency pump motor is

run. When the conditions for an engine stop are met ESC **24** provides the required signals for invoking particular operations. For example, for a remote engine stop, a 1 amp FET low side driver associated with ESC output **136** is deactivated and remote stop relay **114** is activated and remains activated until either multiple position ignition switch **102** is moved to OFF or an engine crank sequence has begun. For a vehicle equipped with an emergency pump motor the remote stop relay **114** remains activated until the ignition switch is turned to off, or the remote switch **110** is held closed for a period exceeding a delay period, or an engine crank is requested. Programming helps determine if the conditions for an engine stop are met, which are: (1) the engine is running; (2) the multiple position ignition switch is NOT in the OFF position; (3) remote switch **110** is depressed; (4) the remote switch **110** has just been depressed; (5) the park brake is set; (6) the status of the engine speed message signal is good; and (7) if a PTO interlock variable is set, the PTO switch is on and has good status. Where the vehicle is equipped with an emergency pump motor then the last condition (no. 7) is simply that the status of the engine speed signal is good. When the engine controller determines that the engine has started it discontinues cranking.

[0041] The engine can be remotely started under the following conditions: (1) The engine is not running; (2) the key is not in the OFF position; (3) the plunger switch is depressed; (4) the plunger switch has just been depressed; (5) the park brake is set; and (6) if the PTO interlock is set, then the PTO switch is on and has good status. For a vehicle with an emergency pump motor condition 6 is replaced with the condition that: the previous sequence with the engine not running was an emergency pump motor operation sequence or the previous sequence was an engine stop sequence using remote switch **110**.

[0042] Emergency pump motor inhibit relay **46** is activated when ignition switch **102** is not in the off position and any one of the three following conditions is met: (1) the accessory signal is ON and NEW, or (2) the engine state is ON and NEW, or (3) the remote switch **110** has just been released. Pump inhibit relay **46** is deactivated when the ignition switch **102** is OFF or all of the following conditions are met: (1) ignition switch **102** is not OFF; (2) remote switch **110** is closed; (3) remote switch **110** has been closed for longer that the programmed delay period after stopping the engine to run the emergency pump motor **59**. Finally, if an emergency pump motor is present it will also run if the multiple position ignition switch **102** is not in the OFF position, the remote switch **110** is depressed, no other functions are currently running (engine stop, cranking, etc.) and the conditions are such that no other function will run.

[0043] Referring particularly to **Figure 11**, execution of the program for a vehicle not having an emergency pump motor begins with determination at step **200** of the position of the ignition switch. If the ignition switch is not in the OFF position the Key_State is true and execution continues to step **202**. If NO the variables Engine_Stop_Relay_Cmd and Engine_Crank_Cmd are reset at step **222** and processing stops. At step **202** ESC **24** determines if remote switch **110** is depressed. If no, the Engine_Crank_Cmd variable is reset at step **224** and processing stops. If a yes resulted at step **202**, execution continues to step **204** where the value of the variable "Tem_Rem_Start_Stop_Plunger" is checked. If the value is "NEW", i.e. the remote switch is newly depressed a value of 1 is stored on a stack in memory, otherwise a value of 0 is entered. A logical AND operation is then implemented on the stack. Next, at step **206** it is determined in the remote stop start PTO interlock is set. If the PTO interlock is set, step **208** is executed to determine if the PTO engagement switch is on and a logical AND operation is performed with 1 and the stack. Otherwise the stack is "ANDed" with 0. At step **210**, following step **208** or along the NO branch from step **206**, it is determined if the Parking brake is engaged. If yes the stack is ANDed with 1, otherwise with zero. Next, at step **212**, if the ignition signal (Ign) to engine controller is on an "AND" operation is preformed on the stack with 1 if the Engine_State has a good status. Otherwise the AND operation on the stack uses a 0. Next, at step **214** the stack is interrogated to see if it has the value 1. If NO the conditions for remote start or stop have not been met and processing is exited. If YES, the conditions for a remote stop or start have been met and step **216** is executed to determine if the engine is running. If YES, the Engine_Stop_Relay_Cmd is set and transistor RD15 **134** is energized. If NO, the engine stop relay command is reset and engine crank command is issued on output **136**.

[0044] The required logic is more complex if an emergency pump motor is provided. Referring to **Figure 12** a flow chart for a vehicle equipped with an emergency pump motor is illustrated. Again processing begins with a determination of the key state at step **230** (i.e. the key is not in the OFF position). If the key is in the OFF position (the NO branch), step **268** is executed to reset each of four variables: (1) Engine_Crank_Cmd; (2) Engine_Stop_Relay_Cmd; (3) EmergencyPump_Inhibit_Relay; and (4) Start_Stop_Timer and the process is terminated. Otherwise processing continues to step **232** which tests to see if one of three conditions is met: (1) if the Accessory_Signal is on or new (in this version the invention also works for ACC being on in the ignition switch **102**); (2) the Engine state is on or new; or (3) the remote switch is newly open. If yes, step **234** is executed to set the emergency pump motor relay and to stop the remote switch closed timer. Following the NO branch from step **232** or after step **234** it is determined if the remote switch is closed. If NO, the routine is exited via step **270** with reset of the engine crank command and the remote switch closure timer. Otherwise step **238** is

executed to determine if the remote switch timer has expired. If yes, the process is exited via step **272** with a reset of the emergency pump motor inhibit relay and turning off the timer. Otherwise, along the NO branch from step **238**, step **240** is executed to put a 1 on the stack if the remote switch is newly closed. Next, at step **242**, if the parameter remote stop/start PTO interlock is set, an AND operation is performed between the stack and 1, but only if the PTO engagement switch is on and has a good status. Otherwise an AND operation is performed between the stack and 0. Next, at step **244**, an AND operation between the stack and 1 is done if the parking brake is set, but otherwise with 0.

[0045] Next, at step **246** it is determined if the signal Ign is high (as reported by the Engine Controller). If YES, step **248** is executed to determine if the engine status is bad and the remote switch is newly depressed. If YES, step **250** provides that a remote shut down flag be set and remote switch depression timer be started along with a stop timer. Following either the NO branch from step **248** or after step **250**, if engine status is bad an AND operation between the stack and 0 is done, but otherwise the AND operation is done against 1. Next, along the NO branch rom step **246** or after step **252**, the value of stack is compared to 1. If it is not 1, processing ceases. Otherwise, along the YES branch it is determined if the engine state is true. If YES, the engine stop relay command and remote shut down flags are set. The remote switch closure timer is started and the engine stop timer is started and processing stops. Following the NO branch from step **256**, the remote switch timer is stopped and the engine stop relay command is reset. Next, at step **262** it is determined if the remote shut down flag is set. If YES, the engine crank command is reset and the remote shut down flag is reset. If NO, the remote shut down flag is set, the remote switch timer is started and the remote switch time. Processing then discontinues.

[0046] The present invention provides a simple, multifunction remote start/stop control system for a utility vehicle that exhibits robustness. A single control may be used to invoke not only starting and stopping, but also to actuate an electric motor-driven pump in case of engine failure.

[0047] While the invention is shown in only one of its forms, it is not thus limited but is susceptible to various changes and modifications without departing from the spirit and scope of the invention.